Oxford Economic Research Associates

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Office of the Rail Regulator

Operating Cost Reductions in Regulated Network Industries

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In undertaking this project, OXERA has taken a wholly independent and impartial approach. The conclusions reached in this document and future documents are those of OXERA and do not represent those of any other party. This does not preclude discussion of the issues with Network Rail, ORR and SRA to enable OXERA to reach independent conclusions.

Executive Summary

The focus of this paper is to provide quantitative evidence on the productivity performance in operating costs of companies that could be deemed comparable to Network Rail. The remit for this top-down study, as set out in the Office of the Rail Regulator (ORR) consultation document in February 2003,[1] was to focus on two principal types of comparator:

- trends in the productivity of overseas railways over the past five years;
- the cost reductions that other network monopolies have been able to achieve since their respective privatisations.

For the first comparator, OXERA examined datasets on overseas railway companies. At first, a dataset of European companies was investigated, but was dismissed after a preliminary analysis exposed significant data consistency problems. Further research identified a dataset on US rail companies, which might have been more appropriate as this would have allowed the construction of Malmquist Indices and the explicit examination of catch-up and frontier shift; however, time constraints meant that this was not pursued for this stage of the research.

This paper therefore focuses on the latter second element—cost reductions in other network monopolies. In more detail, the paper provides estimates on:

- the distribution of performance—based on the experience in other industries, how quickly have cost reductions been made?
  - for a company of average efficiency, a reasonable benchmark can be provided by the performance of the entire industry, as this includes the performance of efficient and inefficient companies in the industry;
  - for a company that is deemed to be relatively inefficient, its potential for improvement may be higher than that suggested by average industry performance;
- a possible longer-term benchmark for general productivity improvements, or frontier shift—in the long run, assuming that Network Rail is reasonably efficient, what additional annual cost reductions could be expected from technological improvements, new management practices, etc, which Network Rail should be able to achieve in addition to the catching up of inefficiencies?

To answer these questions, historic real unit operating expenditure (RUOE) reductions in similar industries are examined. In addition, total factor productivity (TFP) growth

[1] ORR (2003), 'The Interim Review of Track Access Charges: Second Consultation Paper: The Incentive and Financial Framework', February 13th.

comparisons are used to provide an appropriate operating cost benchmark. However, since these measures consider the increase in output relative to increases in *all* inputs (ie, capital, labour and raw materials), they need to be adjusted (based on various assumptions) to remove the effects of capital expenditure (CAPEX) from the productivity estimate. Therefore, the focus of this paper is on comparing RUOE reductions rather than TFP improvements, although the latter are also examined to provide a cross-check on the RUOE-derived benchmarks. A key point that needs to be taken into account is that the analysis assumes that output growth will be self-financing or zero.

Historic-cost reductions achieved by other network utility companies could be used to provide a benchmark range of possible future RUOE reductions for Network Rail. The comparability of these historic performances is very important, and the following adjustments have been made to improve this.

- The analysis focuses on privatised (regulated) network industries, since these are regarded as the companies outside the rail industry whose characteristics match most closely those of a privatised rail infrastructure company. In addition, the TFP performance of several other sectors is examined for cross-reference purposes. However, differences between industries remain and the performance in other rail infrastructure companies has not been examined as a further cross-check.

- The focus on privatised (regulated) network industries suggests that the rates of technical progress in each industry should be similar. However, the telecommunications industry, in particular, would be expected to have far higher technical progress than the other utility industries, and thus would be expected to be able to reduce its RUOE more quickly. Thus, BT's performance has been given less weight in the estimation of an overall productivity performance figure.

- The RUOE reductions have been adjusted for volume growth and the impact of economies of scale. Thus, the adjusted figures provide a benchmark under an assumption of a steady state—ie, it is assumed that future cost drivers, such as volumes, are not expected to show significant growth going forward. However, this adjustment may not be entirely accurate, as the economies of scale estimate is based on other studies not directly associated with the time periods considered.

- In order to take into account the cyclic nature of productivity performance, the TFP comparisons are made over a complete business cycle to avoid misrepresenting the impact of recessionary or growth periods. For the analysis of changes in RUOE in network industries, the effects of privatisation and the regulatory cycle (and the incentives present at the time) have been mitigated by considering, where consistent data is available, the whole time period from privatisation until the present. The relevant regulatory periods are also examined.

- The individual water and sewerage company and electricity distribution company performance results have been averaged across the group of companies in order to mitigate the impact of atypical performance (perhaps due to favourable/unfavourable exogenous factors). In contrast, the figures for the National Grid Company (NGC), Northern Ireland Electricity (NIE) and BT are based on the performance of one company. Although provided over a long period, with adjustments being made to account for extraordinary events where possible, they could therefore represent performance not necessarily comparable, with the other companies examined.

It has not, however, been possible to account in full for other factors that may also affect the applicability of these historic performances, which include the following.

- Different industries may have different proportions of non-controllable costs. Companies with very high proportions of uncontrollable costs will have less potential to reduce their total costs. In this study, it is assumed that the network companies have similar proportions of controllable costs. If using the RUOE reduction range as a benchmark for Network Rail, consideration should be given to its proportion of controllable costs.

- Significant differences in quality enhancements over time may hinder comparisons. For water and sewerage services, some adjustments have been provided by examining base operating costs only. If using the RUOE reduction range as a benchmark for Network Rail, consideration should be given to its future quality-enhancement obligations.

- Historic-cost reductions may need to be adjusted if input price growth is significantly different between industries and over time. Given that the focus of this study is operating expenditure (OPEX), the main input factor is labour. It is assumed that there is no significant difference in wage pressure across the utility industries examined.

- A key driver of cost reductions is the initial efficiency position of a company. No adjustments for this have been made in the figures provided.

- The focus of the analysis is RUOE reductions, and therefore input mix and substitution effects will have an impact on the figures. These efficiency measures only consider one input and one output, and do not take into account exogenous factors or the reason for the intensity of the cost reductions. The inability of the techniques employed in this analysis to account for multiple cost drivers and their interaction could introduce bias into the estimated productivity performance.

Network industry performance

The industries discussed in this paper are:

- water and sewerage;
- electricity (transmission and distribution);
- telecommunications (BT);
- gas (British Gas/Transco).

There are physical differences between the type of activities undertaken by Network Rail and those of its comparators. However, the remit of this analysis is to determine *operating cost-reduction trends* and not to compare the level of operating costs.

The table below presents a summary of the analysis of RUOE trends for selected industries and companies. These trends have been estimated by calculating the average annual growth rate across the period for which data is available, and adjusting these figures for the impact of economies of scale.

Adjusted average annual RUOE reductions (%): summary

	Period	Average annual RUOE reductions (%), adjusted for scale
Water industry	1992/93–2001/02	2.5–2.6
Sewerage industry	1992/93–2001/02	0–0.9
Electricity distribution	1990/91–2000/01	3.1–3.8
NGC	1990/91–2001/02	4.6–5.7
NIE	1992/93–1999/2000	3.9
BT, using exchange lines	1995/96–2000/01	3.4
BT, using call volume	1995/96–2000/01	10.1–10.3
TFP-based RUOE implication	1989–99	0–4.5

Source: OXERA analysis.

The analysis shows a general reduction in RUOE for all industries, and suggests that, on average, and excluding the some of the extreme observations, annual reductions in RUOE of 2.5–5.5% have been achieved since privatisation. TFP growth estimates provide a range of 0–4.5% per annum.

In addition, examining the pattern in performance over time appears to illustrate that an important factor in producing substantial efficiency improvements is the establishment of strong incentives.

The ranges in the table above represent the RUOE reductions actually achieved by the regulated network companies. Targets set by regulators have tended to be lower than these rates in order to provide the privatised companies with incentives to outperform (often referred to as 'carrots').

Distribution of performance

The question of what performance levels have been achieved or the timing of the cost reductions for both the catch-up and the frontier-shift elements is very difficult to answer without resorting to more advanced techniques and making use of more complete datasets.

A more ad hoc alternative could be to assess the historic productivity performance of a sub-sample of companies in the electricity and water industries. A potential problem with this approach, however, is that focusing on sub-sets of data removes the benefit of the law of large numbers—ie, focusing on short time periods or only one company can result in extreme (high or low) estimates of efficiency improvement due to atypical conditions.

The analysis considers:

- the most recent regulatory cycle, due to the relevance of the timeframe (the more recent the period examined, the less likely that underlying economic conditions would be radically different);
- the upper-quartile performance over the period (irrespective of whether this was achieved by the efficient or inefficient companies).

It appears that under relatively higher targets (for both industries), higher productivity gains have been achieved than the identified average for the industries. However, perhaps more significantly, it appears that the regulatory incentives present in the industry have played a key role in performance improvement.

These results are summarised in the table below.

Upper-quartile average RUOE reductions per annum (%): summary

Water industry, upper quartile	
without increased quality obligations	5.6
with increased quality obligations	3.8
Sewerage industry, upper quartile	
without increased quality obligations	5.2
with increased quality obligations	1.9
Electricity distribution, upper quartile	6.0

Source: OXERA analysis.

If Network Rail is assumed to be highly inefficient and thus to have the potential for significant cost reductions and the assumptions mentioned above hold, then these performance ranges may be relevant. However, for a company deemed to be relatively inefficient, the impact of restructuring costs also needs to be considered.

The analysis suggests that the upper-quartile performance of privatised network industries is an annual RUOE reduction of 5% or higher, where no significant quality enhancements are required.

Minimum performance

It is difficult to estimate a frontier-shift benchmark on the basis of simplistic unit cost comparisons, notably because the frontier company or companies will alter over time, such that the performance of one company cannot be used as a direct indication of frontier shift. In addition, there are problems relating to the use of sub-samples and partial productivity measures, as well as the other issues noted above.

Owing to time constraints, the more advanced techniques, such as Malmquist Indices, which might provide more robust estimates of frontier shift, were not examined. The analysis focuses on what other regulated network industries have been asked to achieve by their respective regulators.

The frontier-shift range requested by regulators in privatised industries lies between 0% and 3%. Excluding the frontier-shift assumption of Oftel (for BT) and Ofgem (for the electricity distribution companies), due to differences in the underlying technological growth and incentive issues respectively, provides an estimate of 1–1.5% per annum.

Contents

1. Introduction

As part of Network Rail's Interim Review, the ORR is required to assess a reasonable level of costs for Network Rail to undertake its functions. Several workstreams are being undertaken to assess the appropriate cost level. For this review, the ORR intends to place relatively more weight on bottom-up evidence, considering that this and benchmarking are 'better suited to revealing the speed with which Network Rail can remedy any inefficiency that has emerged in the last two years'.[2]

However, top-down analysis has also been commissioned and is intended to help 'inform [the Rail Regulator's] assessment of the scope for underlying productivity improvements in a railway infrastructure company, which Network Rail should be able to achieve *in addition* to the catching up of inefficiencies'.[3]

This paper presents the results of the top-down workstream, which ORR has commissioned OXERA to undertake. The remit for this top-down study, as set out in the ORR's consultation document in February 2003,[4] was to focus on two principal types of comparator:

- trends in the productivity of overseas railways over the past five years;
- the cost reductions that other network monopolies have been able to achieve since their respective privatisations.

For the first comparator, OXERA examined datasets on overseas railway companies. Initially, it was considered that the International Union of Railways (Union Internationale des Chemins de Fer, UIC) dataset on European companies would enable the most direct comparisons to be made. However, significant data consistency problems meant that use of the UIC dataset was deemed inappropriate. Further research by OXERA identified a dataset on US rail companies which may have been more appropriate for providing cost-trend benchmarks for Network Rail, enabling multiple outputs and multiple exogenous factors (and multiple inputs) to have been considered, and would have enabled catch-up and frontier shift to have been explicitly examined. However, the time constraints of the project meant that this was not pursued for this stage of the research.

This paper therefore focuses on the second element—ie, cost reductions in other network monopolies. The top-down workstream is intended to examine operating costs at an aggregate/company level, using comparisons with other companies or industries. This modelling therefore examines:

- the distribution of performance—based on the experience in other industries, how quickly have cost reductions been made?

[2] ORR (2003), 'The Interim Review of Track Access Charges: Second Consultation Paper: The Incentive and Financial Framework', February 13th.
[3] Ibid.
[4] Ibid.

   - for a company of average efficiency, a reasonable benchmark can be provided by the performance of the entire industry, as this includes the performance of efficient and inefficient companies in the industry;
   - for a company that is deemed to be relatively inefficient, its potential for improvement may be greater than that given by average industry performance;

- a possible longer-term benchmark for general productivity improvements, or frontier shift—in the long run, assuming that Network Rail is reasonably efficient, what additional annual real unit operating expenditure (RUOE) reductions could be expected from technological improvements, new management practices, etc, which Network Rail should be able to achieve in addition to the catching up of inefficiencies?

2. Theory

Productivity measures can be a powerful tool in assessing the performance level of an economic unit. Such measures can be constructed for many different organisational levels including business units, companies, industries and even economies as a whole, and have the advantage of providing a simple summary measure of performance, with growth rates in these measures illustrating improvements in production practices over time. In addition, assuming that the chosen comparators are appropriate, such measures can be used to assess performance between companies, industries or even economies.

This paper uses publicly available information to assess an appropriate rate of reduction in Network Rail's *operating costs* from a top-down perspective. Such target reductions can be derived directly from historic RUOE reductions in similar industries. In addition, total factor productivity (TFP) growth comparisons can be used to provide an appropriate operating cost benchmark. However, since these measures consider the increase in output relative to increases in *all* inputs (ie, capital, labour and raw materials), they require adjustment (using various assumptions) to remove the effects of capital expenditure (CAPEX) from the productivity estimate. Therefore, this paper focuses on comparing RUOE reductions rather than TFP improvements, although the latter are also examined to provide a cross-check on the RUOE-derived benchmarks.

Throughout this paper, it is assumed that output growth will be self-financing or zero. Thus, the paper assesses an appropriate rate of reduction in Network Rail's operating costs for sustaining the network.

Nevertheless, determining future expected efficiency gains is complex. In its 1998 technical consultation paper,[5] Ofwat stated that the assessment of expected future efficiency gains can be separated into two core elements:

- general industry (or minimum) improvements expected from all companies (also known as 'frontier shift'). These improvements refer to underlying improvements in efficiency;
- a catch-up effect, as established by comparative-efficiency exercises—all companies, excluding the most efficient, are expected to improve by catching up with the leading companies, in addition to the general industry improvement.

Because Network Rail is the sole operator of rail network assets in the UK, it is not possible to estimate directly the second of these components using top-down analysis without using international comparisons of rail companies.

The first aim of this study is to assess the potential range of cost reductions under various scenarios—ie, to identify how quickly cost reductions can be achieved by Network Rail. This could be assessed by examining historic productivity and cost reductions in other

[5] Ofwat (1998), 'Assessing the Scope for Future Improvements in Water Company Efficiency', May.

industries. Because these historic performance measures are at an industry level, they will include both the industry's frontier shift and the individual companies' catch-up to the frontier. Hence, these benchmarks will depend on the relative initial efficiency of the companies concerned, as this will affect the catch-up element.

The second aim is to identify a possible longer-term benchmark for general productivity improvements, or frontier shift—ie, in the long run, assuming that Network Rail is reasonably efficient, what additional annual cost reductions could be expected from technological improvements, new management practices, etc? OXERA's process benchmarking work is aimed at identifying Network Rail's potential to catch up to best practice in operating expenditure (OPEX). All the external benchmarks used in this paper incorporate both catch-up and frontier shift, thus this second objective requires the removal of catch-up elements from the external benchmarks.

2.1 Comparisons across industries: general issues

This paper identifies external benchmarks based on comparisons from industries at company or industry level. These only make sense when examining cost-reduction trends, or trends in productivity, as companies in different industries will undertake a number of different functions (implying inconsistency across the units of comparison at the aggregate level).

Such comparisons can potentially identify reasonable benchmarks for future annual cost reductions. However, these methods require careful use to ensure like-for-like comparisons. The issues to consider (and how they are mitigated in this study) include the following.

- *The impact of atypical performance*—focusing on short time periods or only one company can result in extreme (high or low) estimates of efficiency improvement due to atypical conditions. In this study, efficiency performances over reasonably long time periods are examined, with the focus being on the average performance of several companies (where more than one exists in the industry).

- *The comparability of the industries*—this study focuses on privatised (regulated) network industries, as these are regarded as having the most similar characteristics (outside the rail industry) to a rail infrastructure company. In addition, the TFP performance of other sectors is examined as a cross-check.

- *The comparability of volume growth and the impact of economies of scale*—in this study, adjustments to the observed RUOE reduction figures are made using estimates of economies of scale in each industry.

- *The business cycle*—business cycles are periodic swings in an economy's pace of demand and production activity, characterised by alternating phases of growth and recession. TFP growth comparisons are made over a complete business cycle to avoid misrepresenting the impact of recessionary or growth periods.

- *The regulatory cycle*—for the productivity analysis of privatised, network industries, the effects of privatisation and the regulatory cycle (and the incentives present at the time) are likely to overshadow the effects of the business cycle. As such, where consistent data is available, the whole time period from privatisation until the present is examined, alongside the regulatory periods.

- *The controllability of costs*—different industries may have different proportions of non-controllable costs. Companies with very high proportions of uncontrollable costs will have less potential to reduce their total costs. In this study, it is assumed that the network companies have similar proportions of controllable costs.

- *The comparability of quality-of-service performance*—significant differences in quality enhancements over time may hinder comparisons. However, it is difficult to adjust for such differences, as the impact on costs will need to be estimated. Instead, the assumption in this study is that the benchmarks used are reasonable, as most of the industries examined have improved their quality of service over the periods examined, which should be consistent with Network Rail's future operating objectives. In the case of some industries with extensive quality-enhancement programmes (ie, the water and sewerage industry), a more detailed discussion is provided.

- *The comparability of input price growth (eg, wages)*—as a benchmark, historic-cost reductions may need to be adjusted if input price growth in future is estimated to be significantly out of line with the retail price index (RPI). Given that the focus of this study is OPEX, the main input factor is labour. It is assumed that there is no significant difference in wage pressure across the utility industries examined.

- *The comparability of the initial efficiency positions*—the potential for future cost reductions is highly dependent on the initial efficiency position of a company—an inefficient company has greater potential for cost reductions than an efficient one, other things being equal (see section 2.4). While the use of Malmquist Indices is the most direct way to account for this factor, this is beyond the scope of the study. Therefore, more ad hoc, and thus less robust, adjustments are used.

- *The strength of the incentives*—it is also apparent that greater cost reductions can be achieved when the regulatory incentives are stronger.

- *The consistency of the measures*—in this paper, adjustments are made where the measure used is not directly comparable to operating costs (ie, the TFP growth rate figures have been adjusted).

2.2 Measuring productivity and efficiency: partial measures

Some of the most widely used measures of efficiency are partial productivity indicators. A partial productivity indicator at time t (P_t) is a ratio of the outputs produced at time t (Y_t) to the inputs used in time t (I_t) to produce those outputs, as given by Equation 2.1.

$$P_t = \frac{Y_t}{I_t} \qquad \text{Equation 2.1}$$

The growth in this ratio over time can be interpreted as an indicator of efficiency gains. Therefore, efficiency improvement can be monitored through a change in the productivity measure. If the productivity measure increases, it can be inferred that there has been technical progress and/or the use of current inputs has become more efficient. In other words, higher levels of output can be provided without using additional inputs, or the same levels of output can be achieved using lower input levels. One of the most widely used partial productivity measures is output per employee. In the regulated sectors of the economy, substantial attention has been paid to the issue of relative productivity performance, usually described as comparative efficiency.

The two concepts (comparative efficiency and productivity) are closely linked. Comparative efficiency focuses more on one-point-in-time comparisons across similar companies (or equivalent units of analysis), whereas a productivity study generally looks at how efficiency has evolved within one company over a period of time. This can then be compared with the productivity performance of a similar company if desired, although it is crucial that the basis of comparison is valid—ie, that the same underlying outputs, etc, are being compared.

Single factor productivity is the simplest, and most intuitive, measure of productivity. In Equation 2.1, I_t would be replaced with the particular input of interest (eg, labour, capital or raw materials).

Equation 2.1 is a measure of technical efficiency—that is, the ability of a company to produce the required output using the smallest amount of physical input. Partial productivity can also be measured by examining overall (cost) efficiency, which measures the company's ability to produce a given amount of output, while incurring the lowest possible cost. This measurement is more suitable for regulatory purposes, given that the regulatory aim is to assess the efficient cost base of a company. In the case of partial productivity measures for overall efficiency, OP_t, Equation 2.2 is used:

$$OP_t = \frac{C_t}{Y_t} \qquad \text{Equation 2.2}$$

where C_t represents the cost of one factor input (eg, operating costs). This indicator is also referred to as a unit cost, since it indicates the expenditure required to produce a single unit of output. When costs relate to operations and are expressed in real terms—ie, after input price growth is controlled for—the ratio provided is commonly referred to as RUOE. The transformation from current input prices to real input prices is achieved using a cost deflator index, the most common being a consumer or retail price index.

2.3 Total factor productivity

Single factor productivity measures can lead to biased estimates of efficiency improvements as they provide only a partial picture. TFP overcomes the bias in single factor productivity measures by incorporating movements in all relevant factors. Thus, Equation 2.1 becomes:

$$TFP_t = \frac{Y_t}{K_t^{\alpha} L_t^{\beta} M_t^{\gamma}} \qquad \text{Equation 2.3}$$

where: K_t, L_t and M_t are, respectively, capital, labour and raw material inputs, and α, β and γ are the weighting factors (usually constructed to sum to 1) for the various inputs. Ideally, these weights should represent the elasticity of substitution for each input factor, but they are usually chosen to be the share of each input in total costs or revenue. In this measure, the denominator can be interpreted as the potential output available from these inputs; the productivity measure is thus the ratio of actual-to-expected output. In standard theory, growth in TFP over time is interpreted as an outward shift in potential production (ie, a *dynamic efficiency* improvement). This is because it is assumed that the effects of all the physical inputs have been controlled for in the measure, and that these inputs are used as efficiently as possible (although this is often not the case). The remaining growth in output is due to technical progress.

In instances where there are multiple outputs, Y_t would need to represent them all. The standard approach is to weight the different outputs in order to create an aggregate output index by using the share of each output in revenue to reflect its relative importance in the business. However, this is not the correct approach in cases where the firm has some market power. Revenue shares are commonly used because this information is usually readily available, whereas the true output weights should be informed by costs of the business—an area where detailed information is generally lacking. If the market into which the products are sold is competitive, the two are the same, since the company prices its goods at marginal cost. In any case, the TFP measures used in this study are based on whole economy sectors and thus the output measure used is value added; as such, accounting for multiple outputs is not an issue in this case.

2.4 Comparisons of productivity and efficiency measures: issues

Several factors will affect a measure of productivity or efficiency, constructed using Equations 2.1, 2.2 or 2.3. These include:

- volume effects and economies of scale;
- business cycle and utilisation rates (accurately measuring inputs);
- technical progress, or frontier shift;
- catch-up effects;
- input mix and substitution effects (an issue with partial measures only);
- exogenous factors;
- quality aspects of the output measures;
- price differentials, when making comparisons across countries (not relevant to this study).

Each of these issues is discussed below (except for the last factor), along with the implications and approaches used in this study to mitigate their impact in order to provide a reasonable benchmark for Network Rail.

2.4.1 Volume effects

Volume effects arise where there are variable returns to scale in the production process, and they have an impact on how the productivity measures should be interpreted. Increasing returns to scale imply that, as the scale of production increases, output grows by proportionally more than the corresponding increase in the inputs. For instance, an expansion in output will automatically lead to a rise in TFP. In this case, the apparent improvement in the productivity measure is *not* being driven by any underlying technical or dynamic efficiency improvements, but rather by the growth in the inputs, and it is a direct result of the way in which the standard measures of productivity are calculated.

If the extent of the economies of scale is known, this effect is reasonably straightforward to extract from the total movement in productivity, and is adjusted for in this study. For example, the relationship between a standard TFP measure and technical change, when volume effects exist, is shown in the following equation:

$$\hat{A} = T\hat{F}P + (1 - 1/\varepsilon_{CQ})\hat{N} \qquad \text{Equation 2.4}$$

where $\hat{A}$ is defined as true frontier shift, $T\hat{F}P$ as the growth in the standard productivity measure (defined in Equation 2.3 above), ε_{CQ} is the elasticity of costs with respect to output, which captures the extent of the economies of scale, and $\hat{N}$ as the weighted growth in inputs.

When there are increasing returns, the cost elasticity is less than 1—ie, costs rise by less than the increase in output—and the standard measure of TFP grows faster than true technical change as inputs increase.

The cause of this problem could be attributed to the methodology underlying the measurement of TFP. In more detail, the standard weights used for the inputs in the measurement of TFP growth are the share of the total costs represented by each input, which naturally sum to 1. This assumes that, if all the inputs increase, the output increases equiproportionately. However, when inputs increase, their proportionate impact on output is, in fact, greater than 1 (assuming that increasing economies of scale hold). Hence, rather than adjusting the overall TFP measure to extract $\hat{A}$, the true frontier shift (as shown above), the weights could be adjusted to reflect the economies of scale. In general, according to standard TFP methodology, input weights are assumed to sum to 1, and scale effects are assessed afterwards.

The correction for non-constant returns of scale is slightly different for the case of RUOE, although Equation 2.4 provides a reasonably good estimation as well. For this analysis, the returns-to-scale correction adjusts the RUOE of the first year of each time period examined, using Equation 2.5:

$$RUOE_{t-1}^{corrected} = C_{t-1}^{real} \times (1 + \Delta G_{t-1,t} \times \varepsilon_{CQ}) / O_t \qquad \text{Equation 2.5}$$

where C is real costs, $\Delta G_{t-1,t}$ is the change in output levels in the period examined, ε_{CQ} is the elasticity of costs with respect to output and O is output level.

2.4.2 Business cycle

The two aims of this study are to identify a steady-state, long-term benchmark for Network Rail's operating cost reductions, and to assess a range of potential cost-reduction targets under various scenarios. For the former, it is important to consider the impact of the business cycle on observed performance.

It is commonly observed that firms alter the utilisation rate of inputs rather than the actual level employed. Adjustment costs could make it more costly to lay off workers or to mothball plant, compared with using these inputs less intensively during recessions and more intensively during booms. A pro-cyclical pattern is induced in productivity, since the same inputs appear to produce less in periods of recession and more in booms; if the utilisation rate is not considered, this is ascribed to changes in efficiency. Either a control for factor utilisation should be included in a productivity analysis, or any period examined should reflect a full business-cycle movement, so that the cyclical effect disappears from the average (assuming that the utilisation pattern is symmetric).

In most productivity studies, performance over a complete cycle is examined. Alternatively, utilisation rates could be used to adjust the level of the inputs used in the analysis. For example, one way to control partly for the business-cycle effects in the labour force is to use hours of work or full-time equivalents (FTEs), rather than number of employees. For the TFP section, which is based on O'Mahony (2002), the effects of business cycles on labour productivity are partly controlled for using hours of work. Similarly, unit-cost measures partly adjust for this by considering the cost of labour rather than headcount. If there were a shift towards more part-time workers without changing the total number of employees, and such an adjustment were not made, efficiency improvements would be understated.

A further option is to use productivity averages over a full business cycle. This is the approach adopted in this study when examining TFP in other sectors. The average figures produced over the period examined should be free from the influence of cyclical effects since the positive productivity biases in boom years should be cancelled out by the negative biases in the downturns.

For the comparisons using network industries, this effect is less significant, as these industries are less susceptible to the business cycle. Most of the utility industries have seen positive or near-zero volume growth over the periods examined. In addition, long time periods and full regulatory periods are examined to minimise the impact of time-dependent regulatory incentives. Finally, operating costs are used which account for changes in the mix of part-/full-time staff, for example.

2.4.3 Frontier shift

Technical progress and frontier shift are equivalent terms for dynamic efficiency. They describe the characteristic that, over time, a company includes new techniques in its production process. These improvements could be managerial or organisational, as well as the more conventional idea of technical improvements (eg, in the manufacturing plant). Dynamic efficiency requires that, over time, improved techniques are absorbed by the firm so that the chosen production process changes, and technical efficiency is sustained in each period.

Thus, when comparing productivity performance between industries, it is important to recognise that some industries have the potential to achieve large productivity growth through rapid technological development (eg, the telecommunications industry). In other utility sectors (eg, water and sewerage), the rate of technological change is less pronounced, and therefore productivity gains relating to technological development are expected to be less significant in the short to medium term.

The approach adopted in this study is to focus on those industries deemed to be more relevant to the rail industry—ie, those that do not have significant technological progress.

2.4.4 Identifying catch-up and frontier-shift effects

When considering the longer term, further issues need to be examined. Observed performance improvement is driven by technical and dynamic efficiencies. As a consequence, it can be difficult to separate these two effects from a productivity measure. This requires a clear idea of the market leader, and the movements in its productivity index, which can then be attributed to frontier shift. Movements in other firms' productivity indices can be interpreted partly as catch-up to this position *and* partly as technical progress. However, if a number of firms appear to perform well at different times, the picture becomes more complicated and the process of decomposing the effects is substantially more involved.

If the firm is not using its inputs in the most efficient manner—ie, it is technically inefficient—there is greater scope for it to improve. It should be able to 'catch up' to the market leader. Technical efficiency requires that there is no wastage of inputs in the given production process—any reduction in inputs used would result in a decrease in output. This implies that the observed rates of efficiency improvement are dependent on the relative initial efficiency of the companies in the industry.

The technical approach to this problem is to use Malmquist Indices, as was originally envisaged to be used for the US rail company dataset. However, the use of this approach is beyond the scope of this paper. Instead, some general observations can be made.

If the focus of the analysis were on sectors of the economy that are considered competitive, it would be safe to assume that the RUOE figures produced contain minimal catch-up, since market pressures would ensure that inefficient companies do not survive for long.

The RUOE analysis of the network utility industries is slightly more involved, however, as companies were not considered efficient while in the public sector. The general perception is that the 'easy' savings were made immediately after privatisation and that, over time, it has become increasingly difficult to achieve further cost reductions. If this is the observed pattern, some assumptions could be made as to what relates to catch-up and what to frontier shift (ie, the latter would generally be the key driver of efficiency improvements in the more recent period of lower efficiency improvements). However, while this pattern seems to make theoretical sense, continual cost reductions have been made and there has been little evidence of a slowdown in the years since privatisation, although it may now be the case that this slowdown will become apparent. Thus, it is difficult to assess the breakdown between catch-up and frontier shift with some degree of accuracy without using the more technical approaches, which are beyond the remit of this study. Instead, some general comments are made, based on the observed distribution of RUOE reductions, academic and regulatory studies for the industry, and OXERA's experience.

2.4.5 Substitution between factor inputs

An issue specific to partial productivity and efficiency measures is that increases in the metric cannot be identified solely as technical improvements, since *changes in the choice of input mix* will have an influence. For example, if a firm replaces much of its billing workforce with an improved information technology system, per-capita output will increase significantly, although productive efficiency could fall when both inputs are considered. A similar problem arises from outsourcing, in that the labour productivity measure could increase substantially, concealing the growth in input costs.

The trade-off between OPEX and CAPEX can be both operational (as discussed above) as well as the result of changes in accounting policy.

The approach used in this study is to assume that, when using RUOE as a basis for the benchmark for Network Rail's operating cost reduction, capital substitution is of a similar order of magnitude across the regulated network utilities, given that they have similar incentives. (Where this is unlikely to be the case—for example, in the electricity distribution industry—it is noted, and the direction of the impact stated.)

2.4.6 Exogenous factors

Using the change in productivity over time as a benchmark for future performance assumes that the past performance of a company is a sensible yardstick of future performance. Therefore, if there are likely to be substantial *changes in the operating* *environment* of part of the business or changes in *exogenous factors*, this technique could be less appropriate. For example, some companies have achieved substantial productivity gains over a given period owing to, for example, the abolition of restrictive practices.

Thus, if the productivity measure is being used in setting targets for future performance, it is important to know whether past gains have been achieved because of strong product growth, rapid catch-up to a world leader, or as a result of exogenous factors. Whether equivalent gains will be feasible in the future will depend on whether the underlying conditions are likely to persist. Where possible, these factors are taken into account.

The approach used in this study is to exclude periods materially affected by exogenous factors as far as possible. For example, periods excluded could be those affected by cost reallocations out of the regulated part of the business; significant sectoral restructuring (such as mergers); and higher costs due to the wider scope of activity of the regulated company, as required by the regulator. It is not possible to account for all exogenous factors under such an approach. Alternatively, econometric modelling, or similar techniques, could be used—such an approach could be feasible for the US dataset, for example.

2.4.7 Quality

All the characteristics of the chosen output(s) should be reflected in the measure used. This has been summarised as *quality*, but could also encompass safety or environmental dimensions of the output. If the output does not accurately reflect all the dimensions of the product, changes in quality will appear as changes in the efficiency measure. For example, if investment is increased (or more people are employed) to produce the same amount of a good, but to a higher standard, productivity will appear to have fallen. Similarly, a productivity target that disregards the quality of the output provides incentives to produce a lower-quality product with fewer inputs—a practice that will *appear* to yield productivity gains. This scenario may be avoided by implementing an index of standards which must not fall while the productivity gains are delivered.

Quality changes in the input measures should also be considered. If the skill level of the workforce is improving, but the number of hours worked is not increasing, productivity may appear to rise, although it should be identified with the increasing capacity of the workforce. Similarly, if the type of capital employed changes in nature, and this is not adequately captured in the price, these improvements will appear as productivity gains rather than being attributed to the input itself. Over a short period of time this problem is unlikely to have a substantial impact on the interpretation of productivity.

It is difficult to account for changes in quality. The approach taken in this study is to identify a benchmark for Network Rail under the assumption of a steady state—ie, the target is set on the basis of no significant future requirements for quality enhancement. As such, in industries with extensive quality-enhancement programmes, such as the water and sewerage industry, additional productivity measures are provided using base OPEX, which excludes increased costs associated with quality enhancements. More generally, most utilities have improved their quality, and thus, if anything, the benchmarks under-report the efficiency improvements. However, if it is envisaged that, over the period to which the long-term benchmark is to be applied, Network Rail will be required to improve quality to a far greater extent than other network utilities have historically, the benchmarks derived in this study will need to be revised.

3. Performance of UK Network Utility Companies

This section examines the efficiency improvements of other UK network companies.

In order to be relevant, comparisons need to be made on the most like-for-like basis possible. Thus, the first approach to be considered was the examination of rail network companies in other countries, as these might provide the most direct comparisons. However, data consistency problems with the European companies limited the potential dataset to US rail companies. In addition, one concern regarding the use of the US dataset was that the US companies tend to provide network infrastructure services mainly for freight companies, while Network Rail provides infrastructure services for a network with mixed, although mostly passenger, traffic. However, this difference in such operating conditions should not be that significant, since the focus of this analysis is to provide benchmarks for potential *rates* of improvement in operating costs (excluding maintenance), a cost category whose rate of change should not be overly affected by the traffic mix of the network. Such comparisons would have enabled multiple outputs and multiple exogenous factors (and multiple inputs) to be considered, and the estimation of Malmquist Indices would have been possible. Such an approach might have provided a more accurate assessment of efficiency improvements over time, and would have enabled catch-up and frontier shift to be estimated separately, including examining the link between relative inefficiency and future productivity improvements. However, the limits on the scope of the project meant that this was not pursued for this stage of the research.

This section therefore examines RUOE reduction trends in the UK network utility sectors. The main objective of this analysis is to estimate the operating cost trends in industries that are deemed to provide services comparable to those of the infrastructure services for the UK rail network, in order to use them as benchmarks for Network Rail's future productivity performance.

The choice of the comparator industries was based on two criteria:

- the nature of their work must closely match that of Network Rail—ie, the provision of network infrastructure services. This criterion is significant because network industries share similar types of activities and certain characteristics, such as increasing returns to scale and density, and the long-term effects of past investment on current efficiency levels;

- the industry must be subject to economic regulation.

Based on the above, the industries discussed in this paper are:

- water and sewerage;
- electricity (transmission and distribution);
- telecommunications (BT);
- gas (British Gas/Transco).

There are physical differences between the type of activities undertaken by Network Rail and those of its comparators. However, the remit of this analysis is to determine *operating cost-reduction trends* and not to compare the level of operating costs.

The analysis provides two types of RUOE change estimates for some industries examined. Common to all industries is the average RUOE change, which is defined as the average value of the annual RUOE changes. For multi-company industries, such as water and sewerage, and electricity distribution, the weighted average RUOE change is also reported, which is defined as the annual percentage difference of the aggregated industry-wide RUOE (in turn, defined as the sum of costs divided by the sum of outputs in a single year). In all cases, a positive value represents productivity growth, while a negative value signifies productivity regression.

All costs are in real terms, with the base year being the final year of analysis in each case.

3.1 BT

BT was privatised in 1984, although, owing to changes in regulatory accounting guidelines, consistent data is only available from the 1996 reporting year onward.

In terms of setting a general long-term productivity trend benchmark, it seems likely that, because of the characteristics of the telecommunications sector, BT's historic performance will provide too high a target compared with that of the other network industries. Indeed, when examining BT's performance over the period 1984–94, Bishop and Green state that:

> BT's more rapid TFP growth owes something to faster technological innovation …more important, however, *may* have been changes to its competitive environment.[6] [emphasis added]

The authors did not, however, attempt to quantify either effect.

BT's RUOE has been calculated using two output measures: exchange line connections and call volume. Call volume is likely to be the more appropriate output measure, since the exchange line connections measure would not necessarily capture the increasing number of services provided through a single connection, or network capacity provided through the use of this connection, making this measure unlikely to reflect adequately the economies of scale of this industry.

[6] Bishop, M. and Green, M. (1995), 'Privatisation and Recession—The Miracle Tested', Discussion Paper 10, Centre for the Study of Regulated Industries.

Table 3.1: Annual average RUOE reductions (%) between 1996/97 and 2001/02—BT

	Average RUOE reductions			Average RUOE reductions adjusted for scale		
	Call volume	Call volume (excluding other calls)	Exchange line (no. of connections)	Call volume	Call volume (excluding other calls)	Exchange line (no. of connections)
1995/96–1996/97	13.7	12.6	9.3	13.2	12.2	9.2
1996/97–1997/98	4.1	–0.2	–0.7	3.6	–0.3	–0.7
1997/98-1998/99	16.6	10.2	12.9	16.2	10.3	12.8
1998/99–1999/2000	6.6	19.2	–2.8	5.6	17.3	–3.0
1999/2000–2000/01	13.3	13.3	–1.1	11.9	11.9	–1.2
2000/01–2001/02	–12.3	–12.2	–32.3	–14.1	–14.0	–32.4
Average performance						
1995/96–2001/02	7.0	7.1	–2.4	6.1	6.3	–2.5
1995/96–2000/01	10.9	11.0	3.5	10.1	10.3	3.4

Note: The OPEX figures used to calculate RUOE include access, network and retail costs. Call volume includes local, national, international fixed-to-mobile calls and other calls (operator calls, speaking clock and calls to Internet service providers).
Source: BT regulatory accounts; Oftel, Market Information; and OXERA analysis.

An important issue with using BT's RUOE reductions as benchmarks for Network Rail is the large output growth experienced by BT during the timeframe (approximately 11% per annum). As a result, the productivity measure needs to be corrected for the effects of scale economies. The analysis assumes that BT's elasticity of scale is equal to 0.9, which is a moderate assumption when call volume is used as an output. BT's estimated annual average adjusted RUOE reduction over the whole period of the analysis is approximately 6% (using call volume as the preferred output measure).

However, the productivity change estimate over the whole period is biased downwards. This is because, during 2001/02, the costs pertaining to network and access assets increased significantly, mainly owing to company restructuring and the adoption of new activities that incur new cost categories, such as those pertaining to BT Retail Narrowband Access. Excluding the final year from the analysis provides an RUOE estimate in the range of 10.1–10.3% per annum (or 3.4% per annum using exchange line connections as the output measure).

One method of taking into account all the possible outputs of BT is to aggregate the estimated average RUOE reductions of call minutes and exchange line connections. This aggregation requires weights to be assigned to each output, and these should be informed by the share of operating costs of each output. However, since this information is usually unavailable, shares of revenue are used instead. The weights used in this analysis are based on O'Mahony (1997)[7] and are 75% for call volume and 25% for exchange line connections. Based on this weighting and using call volume (excluding other calls), the productivity growth estimates for BT are as shown in Table 3.2

Table 3.2: Annual average RUOE reductions (%) between 1996/97 and 2001/02 using a composite output—BT

	Average RUOE reductions	Average RUOE reductions adjusted for scale
1995/96–1996/97	11.8	11.5
1996/97–1997/98	–0.3	–0.4
1997/98-1998/99	10.9	10.9
1998/99–1999/2000	13.7	12.2
1999/2000–2000/01	9.7	8.6
2000/01–2001/02	–17.2	–18.6
1995/96–2001/02	4.8	4.0
1995/96–2000/01	9.1	8.6

Note: RUOE includes access, network and retail OPEX.
Source: BT regulatory accounts; Oftel Market Information; and OXERA analysis.

Based on the composite output measure, the average annual adjusted RUOE change for the whole period examined is 4%. If the last year of the analysis is excluded, because of the comparability issues previously discussed, the average annual RUOE reduction estimate is 8.6%.

The use of these annual RUOE changes to inform possible cost-reduction targets for Network Rail could be considered inequitable by the company, given the technological progress of the telecommunications industry and that the RUOE reduction trends in the other privatised network companies examined are significantly lower.

3.2 Electricity industry

The electricity industry has gone through significant changes since privatisation, the most important being the separation of the business into its component parts and the introduction of competition into the non-network parts of the business.

- The business was split into electricity generation, electricity transmission (transmitting electricity from the power stations to local distribution networks at grid supply points), electricity distribution (transferring electricity from supply points on the national grid to final customers), and electricity supply (which deals with the contracts with customers for the delivery of electricity).

[7] O'Mahony, M., Oulton, N., and Vass, J. (1997), 'Labour Productivity in Transport and Communications: International Comparisons', National Institute of Economic and Social Research, Discussion Paper No. 117, April.

- Electricity generation and supply are competitive businesses. Transmission and distribution, due to their national and regional networks respectively, represent national and regional monopolies, and are therefore subject to economic regulation.

Thus, RUOE reductions are reported for the transmission and distribution business, since these aspects of the electricity industry are similar to aspects of Network Rail—ie, the maintenance and development of a network under economic regulation.

3.2.1 Distribution business

Electricity distribution in England, Wales and Scotland is carried out by 14 regional companies, which were formed from the regional Area Boards, their predecessors before privatisation. The data available for the electricity distribution industry, in the form of published regulatory accounts, is not as robust as that for the water and sewerage industry. This is the result of disparate accounting practices between the companies in the industry prior to the 1998 reporting year. This lack of standardisation in the reporting of costs led Ofgem, the industry's economic regulator, to undertake a complete restating of companies' costs for the 1997/98 reporting year, in order to base its 1999 price-control review on comparable costs.

Volume growth has been 1.4% per annum for the period since privatisation. Since theory suggests that the industry benefits from considerable economies of scale, this output growth may introduce upward bias in the reported RUOE.

The RUOE reductions presented in Table 3.3 are based on total operating costs, as reported in the companies' regulatory accounts. This cost measure includes depreciation, which is a proxy of CAPEX and, as such, should be excluded from the analysis; however, the use of depreciation was deemed necessary due to the wide range of capitalisation policies adopted by the distribution companies.[8] Nevertheless, the RUOE analysis was duplicated using OPEX excluding depreciation, giving an estimated range of productivity gains, *without* adjusting for scale effects, equal to 4.8–5.9% (excluding the final year of the analysis), as opposed to 3.4–4.1% for the equivalent figures including depreciation. This range is, however, highly influenced by the productivity estimates of two periods (namely 1995/96–1996/97 and 1998/99–1999/2000), and, as such, less confidence should be placed on it.

[8] Preliminary analysis of RUOE reductions that were based on operating costs excluding depreciation charges revealed unacceptably high fluctuations in the RUOE measure. These fluctuations are heavily influenced by differences in capitalisation policies both between companies and within the same company across time.

Table 3.3: Annual average RUOE reductions (%) between 1990/91 and 2000/01—electricity distribution in Great Britain

	Average RUOE reductions	Average RUOE reductions adjusted for scale	Weighted average RUOE reductions	Weighted average RUOE reductions adjusted for scale
1990/91–1991/92	2	1.6	1.9	1.6
1991/92–1992/93	2.1	2.1	3.6	3.7
1992/93–1993/94	–3.2	–3.7	–2.0	–2.5
1993/94–1994/95	3.7	3.5	4.6	4.4
1994/95–1995/96	9.4	8.6	10.6	9.7
1995/96–1996/97	8.5	8.2	8.4	8.1
1996/97–1997/98	3.4	3.2	3.4	3.2
1997/98–1998/99	–1.2	–1.8	0.2	–0.3
1998/99–1999/2000	6.2	5.9	6.5	6.2
1999/2000–2000/01	18.6	19.9	19.8	19.4
Average performance				
1990/91–1994/95	1.2	0.9	2.0	1.8
1994/95–1999/2000	5.3	4.8	5.8	5.4
1990/91–2000/01	5	4.7	5.7	5.3
1990/91–1999/2000	3.4	3.1	4.1	3.8

Note: The OPEX figures include depreciation and uncontrollable costs (eg, NGC rates) but exclude exceptional items.
Source: Company regulatory accounts and Electricity Association (various), *Electricity Industry Review*.

One useful indicator of productivity performance is the productivity gains achieved during a full regulatory period, since this allows for the periodicity of regulatory incentives to be taken into account. In the electricity distribution industry, the annual RUOE reductions achieved during the last, full, regulatory period, adjusted for scale are estimated to be in the range of 4.8–5.4%.[9]

In 1999/2000, Ofgem adopted the use of historic-cost accounting (HCA) for the preparation of companies' regulatory accounts (current-cost accounting, or CCA, was previously used). However, since both HCA and CCA figures were available for this period, this change of practice had no impact on this analysis. Nevertheless, the large RUOE reductions for the last period of the analysis, 1999/2000–2000/01, suggest that this period may bias the benchmark for Network Rail. This large reduction could be explained by the following changes that took place in this period.

[9] During the period examined, no rolling OPEX mechanism was in place, thus companies had a significant incentive to reduce their costs at the beginning of the regulatory review period—see section 5.2.

- During the 1999 distribution price-control review, some costs were reallocated from the electricity distribution businesses to electricity supply. On average, these reallocations resulted in a reduction of approximately 8% in the companies' total allowed revenues. This impact can be seen in the sharp increase in RUOE reductions between 1999/2000 and 2000/01.

- In the 1999 distribution price-control review, Ofgem determined that there was scope for large efficiency gains to be achieved in the industry, and therefore set relatively high targets for some companies. In addition, it did not introduce a rolling OPEX mechanism, thus companies had a strong incentive to make their efficiency savings as soon as possible—this time dependency of incentives and the consequent front-loaded profile in cost reduction can also be seen in Table 3.3 over the previous regulatory period, 1994/95 to 1999/2000. (The distribution of observed performance is discussed in section 5.2.)

For the above reasons, the 2000/01 period should be removed from the estimation of RUOE reductions, since the industry cannot be considered to be in a stable state, which is a necessary condition for this analysis.

Owing to the volume growth of the industry, adjustments for the scale effects are required in order to produce equitable RUOE estimates. This analysis uses a scale elasticity estimate of 0.721, consistent with the findings of a study by Burns and Weyman-Jones.[10]

The adjusted figures suggest an annual average RUOE reduction benchmark of approximately 3.1–3.8%.

3.2.2 Northern Ireland Electricity

NIE's RUOE is reported separately because this company is responsible for both transmission *and* distribution in Northern Ireland. In addition, the company is regulated by the Office for the Regulation of Electricity and Gas (Ofreg), rather than Ofgem, as is the case for the distribution network operators in Great Britain. Another distinctive feature of Northern Ireland is that the electricity industry was restructured during 1992, two years after the privatisation of the electricity companies in England and Wales. This two-year difference implies that NIE's regulatory cycle is out of line with that of its counterparts in Great Britain. NIE also experienced significant output volume growth during the period examined in this analysis, with an estimated average annual growth of 2.8%.

[10] Burns, P. and Weyman-Jones, T.G. (1994), 'The Performance of the Electricity Distribution Business: England and Wales 1971–1993', Centre for the Study of Regulated Industries, Chartered Institute of Public Finance and Accountancy, May.

Table 3.4: Annual average RUOE reductions (%) between 1992/93 and 1999/2000—NIE

	RUOE reductions	RUOE reductions adjusted for scale
1992/93–1993/94	4.9	4.1
1993/94–1994/95	6.7	6.3
1994/95–1995/96	5.9	5.1
1995/96–1996/97	–1.2	–1.9
1996/97–1997/98	12.9	12.5
1997/98–1998/99	–5.1	–6.3
1998/99–1999/2000	10.6	10.1
1999/2000–2000/01	2.6	2.0
2000/01–2001/02	2.1	3.4
Average performance		
1992/93–1996/97	4.1	3.4
1996/97–2001/02	4.6	4.3
1992/93–2001/02	4.4	3.9

Notes: NIE's costs include both transmission and distribution. OPEX is based on CCA and includes depreciation, uncontrollable costs and exceptional items.
Source: Information provided to OXERA by NIE.

The annual average adjusted RUOE reduction for NIE for the whole period examined was 3.9%.[11] When considering the RUOE change for the latest, full regulatory period, the productivity growth estimate is 4.3%per annum.

The OPEX figure used to estimate the RUOE change for NIE includes depreciation in order to obtain a figure that is more comparable with those produced for the UK companies. When depreciation is excluded from the analysis, the average annual RUOE reduction without adjusting for scale is estimated to be approximately 5.3%.

3.2.3 Electricity transmission

The transmission business in England and Wales is carried out by the NGC, which took over the transmission-related operations of the Central Electricity Generating Board (CEGB), which was responsible for electricity generation and transmission prior to privatisation.

Electricity transmission in England and Wales has seen a significant decrease in RUOE from 1990/91 to 2000/01, a period that is also characterised by increasing output volumes (with an estimated average annual growth of 1.3%). In 1998 operating costs rose sharply due to NGC taking over the operations and management of the Transmission Services

[11] The adjustment for scale was carried out using the same scale elasticity estimate as for the electricity distribution companies in Great Britain and NGC.

Scheme, which was previously the responsibility of the Electricity Pool of England and Wales. However, data supplied by NGC allowed the effect of these new output requirements to be quantified, enabling a consistent picture of the company's productivity performance to be obtained. Table 3.5 reports the RUOE reductions based on two measures of operating cost: including and excluding rates (ie, uncontrollable costs). The reason for this distinction is the high proportion of rates to operating costs observed for NGC, measuring up to 30%. Since the proportion of uncontrollable costs for Network Rail is approximately 18% of total OPEX, a benchmark for informing Network Rail's possible future RUOE reduction is probably between the estimated RUOE reductions for NGC using both controllable and uncontrollable costs.

Table 3.5: Annual average RUOE reductions (%) between 1990/91 and 2000/01—NGC

	Excluding rates		Including rates	
	RUOE reductions	**RUOE reductions adjusted for scale**	**RUOE reductions**	**RUOE reductions adjusted for scale**
1990/91–1991/92	–16.7	–16.9	–14.9	–15.1
1991/92–1992/93	9.4	9.4	7.9	8.0
1992/93–1993/94	17.4	17.1	14.2	13.9
1993/94–1994/95	17.9	17.5	14.1	13.8
1994/95–1995/96	7.3	6.6	6.8	6.2
1995/96–1996/97	10.2	9.9	6.3	5.9
1996/97–1997/98	15.7	15.3	11.0	10.6
1997/98–1998/99	3.7	3.4	8.2	7.9
1998/99–1999/2000	–3.0	–3.4	–4.5	–4.9
1999/2000–2000/01	2.8	2.3	3.7	3.2
2000/01–2001/02	1.2	1.0	1.3	1.0
Average performance				
1990/91–1996/97	7.1	6.8	5.6	5.4
1996/97–2000/01	5.9	5.5	4.9	4.6
1990/91–2001/02	6.0	5.7	4.9	4.6
1991/92–2001/02	8.3	7.9	6.9	6.6

Note: Operating costs are total operating costs minus depreciation and Transmission System Scheme/Balancing Services Incentive Scheme charges. Output is units of electricity transmitted, adjusted for weather.
Source: Information provided to OXERA by NGC.

The annual average adjusted RUOE reductions for NGC are estimated to be 5.7% when controllable costs are used and 4.6% when operating costs include rates. However, the first year of the analysis cannot be considered representative of a steady state since this was the first year of privatisation, when NGC incurred significant restructuring costs relating to its new commercial/charging functions and the implementation of financial and administrative systems and control. Removing this year from the analysis increases the average annual RUOE reductions of NGC to 7.9% for controllable OPEX and 6.6% when rates are included. The choice between including or excluding the first year of the data will depend on the purpose of the analysis. For a medium- to long-term target, the first year of the analysis should be excluded. On the other hand, for a company deemed to be relatively inefficient, restructuring costs need to be considered and thus the first year should be included.

The annual average RUOE reductions achieved by NGC during the latest full regulatory period, adjusted for economies of scale, are 5.5% for controllable OPEX and 4.6% when rates are included. Due to the aforementioned disparity in the proportion of uncontrollable costs between the companies in question, more weight should be given to the upper range of this estimate. Most of the large productivity gains seem to be achieved during the first six to seven years after privatisation, with the later periods revealing a more modest annual productivity change. This might be due to the company becoming more efficient over the period, or to the new obligations it took on during the latter years, since it could be argued that, at that time, the focus of the management would be to incorporate the new activities into the existing operations, rather than seeking to achieve productivity gains in those areas.

3.3 Water and sewerage industry

The water and sewerage industry in England and Wales comprises privatised water and sewerage companies (WASCs) and water-only companies (WOCs). At privatisation, there were ten WASCs and 22 WOCs, and while the number of WASCs has remained constant, the number of WOCs has decreased to 12 due to mergers and acquisitions in the industry. The RUOE changes presented below are based on a balanced panel—ie, for the purposes of the analysis, the data was adjusted to create the composite companies that are currently active in the industry.[12]

Since privatisation, the water and sewerage industry has undertaken a quality-enhancement programme that requires significant investment in infrastructure. This investment will result in additional OPEX to operate the new assets, and, unless adjusted for, the RUOE reduction figures will suggest that lower efficiency improvements have occurred in the water industry than has actually been the case. This OPEX increase due to new quality obligations is not controlled for in Table 3.6.

[12] Thus, for example, although data on Anglian and Hartlepool is available separately prior to 2001, it is the composite company, Anglian and Hartlepool, that is used to assess the RUOE change from the starting point of the analysis.

Table 3.6: Annual average RUOE reductions (%) between 1992/93 and 2001/02—water services

	Average RUOE reductions	Average RUOE reductions adjusted for scale	Weighted average RUOE reductions	Weighted average RUOE reductions adjusted for scale
1992/93–1993/94	–0.5	–0.5	–1.5	–1.4
1993/94–1994/95	4.0	4.0	3.0	2.9
1994/95–1995/96	6.0	5.8	5.9	5.7
1995/96–1996/97	1.0	1.1	0.3	0.4
1996/97–1997/98	–0.4	–0.3	0.2	0.3
1997/98–1998/99	0.7	0.9	1.5	1.6
1998/99–1999/2000	2.3	2.3	3.8	3.8
1999/2000–2000/01	5.9	5.9	6.7	6.7
2000/01–2001/02	3.2	3.1	3.1	3.0
Average performance				
1990/91–1994/95	1.8	1.7	0.8	0.8
1994/95–1999/2000	1.9	2.0	2.3	2.4
1999/2000–2001/02	4.6	4.5	4.9	4.9
1992/93–2001/02	2.5	2.5	2.6	2.6

Note: OPEX excludes depreciation, uncontrollable costs (local authority rates, Environmental Agency charges, etc) and exceptional items.
Source: Ofwat, June and July Returns.

The above table suggests moderate annual average RUOE reductions in the water industry, approximately equal to 2.5%, with the largest improvement in productivity growth taking place in the last two years of the analysis. The ten-year average RUOE change figure remains the same whether or not the adjustment for returns to scale is implemented, due to output levels remaining roughly constant throughout the period examined. The analysis assumes modest returns to scale (equal to 0.96), based on an overall water service model.[13]

When examining the most recent full regulatory cycle, the annual average productivity performance of the industry is estimated to lie between 2% and 2.4%, a range that is similar to the industry's overall performance.

The RUOE change analysis was repeated using base service OPEX figures—ie, figures adjusted for the increased expenditure relating to enhanced levels of service and quality. The analysis was carried out for the most recent regulatory period and the results are presented in Table 3.7.

[13] Competition Commission (2000), 'Mid Kent Water Plc: A Report on the References under Sections 12 and 14 of the Water Industry Act 1991', p. 267.

Table 3.7: Annual base RUOE reductions (%) between 1992/93 and 2001/02—water services

	Average RUOE reductions	Weighted average RUOE reductions
1994/95–1995/96	6.7	6.4
1995/96–1996/97	3.1	3.8
1996/97–1997/98	0.6	1.5
1997/98–1998/99	1.7	2.1
1998/99–1999/2000	2.7	4.5
1994/95–1999/2000	3.0	3.6

Note: Base OPEX excludes depreciation, uncontrollable costs (local authority rates, Environmental Agency charges, etc), exceptional items and OPEX on quality enhancement.
Source: Ofwat, June Returns.

The average annual RUOE change estimated after adjustments for enhanced levels of service and quality, but without adjustments for volume growth, lies between 3% and 3.6%, compared with the range of 1.9–2.3% for the unadjusted RUOE estimate from Table 3.6.

The analysis of productivity growth for the sewerage services is less straightforward due to information on both costs and outputs for the period between 1992/93 and 1994/95 displaying a high degree of variability. The RUOE analysis in the sewerage services uses total connected population as an output, instead of a more intuitive variable such as total sewage load received, mainly due to this variable being more consistent in the early periods of the analysis. Furthermore, experience from Ofwat's detailed relative efficiency modelling suggests that total connected population is more cost-reflective than almost any other operational factor or output, and when consistent information is available for both variables (ie, total connected population and total load received), the degree of correlation between the two is very high.

Table 3.8: Annual average RUOE reductions (%) between 1992/93 and 2001/02—sewerage services

	Average RUOE reductions	Average RUOE reductions adjusted for scale	Weighted average RUOE reductions	Weighted Average RUOE reductions adjusted for scale
1992/93–1993/94	8.0	8.0	8.9	8.9
1993/94–1994/95	–8.3	–8.3	–6.8	–6.8
1994/95–1995/96	–6.9	–6.8	–7.4	–7.4
1995/96–1996/97	1.2	1.2	1.6	1.6
1996/97–1997/98	2.3	2.3	2.8	2.7
1997/98–1998/99	–0.7	–0.7	–1.4	–1.4
1998/99–1999/2000	0.6	0.6	0.8	0.7
1999/2000–2000/01	1.7	1.7	3.1	3.1
2000/01–2001/02	–4.9	–4.9	–1.1	–1.2
Average performance				
1994/95–1999/2000	–0.7	–0.7	–0.7	–0.8
1999/2000–2001/02	–1.6	–1.6	1.0	1.0
1992/93–2001/02	–0.8	–0.8	0.1	0.0
1995/96–2001/02	0.1	0.0	0.9	0.9

Note: OPEX excludes depreciation, uncontrollable costs (local authority rates, Environmental Agency charges, etc) and exceptional items.
Source: Ofwat, June Returns.

The aforementioned variability in the data has a significant impact on the results of the analysis during the first years after privatisation, as Table 3.8 reveals. Because the productivity movement estimates produced for this period were very dissimilar to those of the later years, it was considered that they represented atypical performance and were thus excluded from the overall productivity estimate of the sewerage service. Therefore, only a six-year average productivity change estimate is reported. The results from the analysis suggest that, for the period where consistent data is available, the productivity change has been quite variable, with the largest productivity improvements taking place during 1995/96.

Taking the above into consideration, the annual productivity change in sewerage services is estimated to lie between 0% and 0.9%. However, there are potential problems with the OPEX figure used to produce these estimates, due to costs relating to enhanced levels of service not being controlled for. There has been considerable investment in quality in sewerage services since 1995/96 (for most of the industry—some individual companies initiated their quality-enhancement programme in earlier years), with the implementation of environmental programmes such as the Urban Waste Water Treatment Directive. The quality-enhancement programme in sewerage services was (and for most companies still is) much more extensive than that seen in the water services, and thus the common perception in the industry is that its influence on OPEX is expected to be greater. The execution of these large projects might explain the divergence of productivity growth between these two services, given that managerial concerns at the time were more likely to revolve around the actual planning and implementation of the quality-enhancement programme than in making productivity gains. Table 3.9 presents the RUOE change estimates for the most recent, full regulatory period when the extra costs relating to the provision of enhanced quality levels are removed from the analysis.

Table 3.9: Annual RUOE reductions corrected for the effects of investment in quality between 1994/95 and 1999/2000—sewerage services (%)

	Average RUOE reductions	Weighted average RUOE reductions
1994/95–1995/96	–4.4	–5.4
1995/96–1996/97	1.0	1.3
1996/97–1997/98	8.7	8.4
1997/98–1998/99	3.7	2.6
1998/99–1999/2000	6.6	6.4
Average performance		
1994/95–1999/2000 average	3.1	2.7

Note: OPEX excludes depreciation, uncontrollable costs (local authority rates, Environmental Agency charges, etc) and exceptional items.
Source: Ofwat, June Returns.

The average annual RUOE change for the sewerage services, estimated after adjustments for enhanced levels of service and quality, but without adjustments for volume growth, lies between 2.7% and 3.1%, compared with the point estimate of approximately –0.7% for the unadjusted RUOE reduction from Table 3.9.

3.4 British Gas/Transco

The most suitable comparison in the gas industry for Network Rail would be companies that provide storage and transportation infrastructure services. However, due to the intense restructuring activity that has taken place in recent years and multiple changes to the functions of British Gas/Transco, robust data that covers the provision of the above services is not available, and thus any productivity analysis would be biased. For these reasons, the productivity analysis of British Gas/Transco was abandoned.

4. Sectoral TFP Comparisons

In addition to the comparisons of RUOE trends, a cross-check is undertaken in this section using sectoral TFP performance.

Historic comparisons of TFP growth rates for UK industry sectors provide useful information on the future potential for productivity improvements. O'Mahony (2002) provides estimates of UK sectoral TFP growth rates.[14] Table 4.1 summarises these findings.

Table 4.1: UK historic sectoral TFP, 1989–99

	%
Agriculture, forestry and fishing	1.89
Mining and oil refining	4.65
Electricity, gas and water	3.45
Manufacturing	1.61
Construction	0.69
Transport and communications	3.77
Distributive trades	–0.08
Financial and business services	0.42
Miscellaneous personal services	0.54
Non-market services	2.06
Total	
All sectors	**1.14**
Market sectors	**1.02**

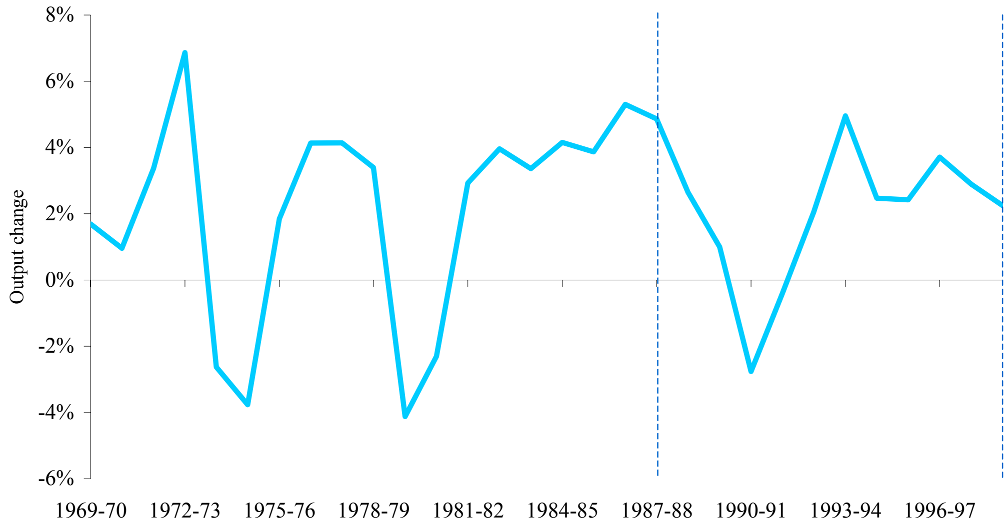
Source: O'Mahony (2002).

O'Mahony's published figures cover the periods 1989–99, 1989–95 and 1995–99. Table 4.1 presents the figures for the 1989–99 period only. This is because the other available time series cover relatively short periods for the purposes of productivity analysis. Moreover, the 1998–99 period appears to represent a complete business cycle (see below).

Business cycles are characterised by alternating phases of growth and recession. Therefore, the most straightforward way to assess the duration of a business cycle is to plot the growth of output over time, as shown in Figure 4.1.

[14] O'Mahony, M. (2002), 'Britain's Relative Productivity Performance: Updates to 1999', Final Report to the Department of Trade and Industry/HM Treasury/Office of National Statistics, March.

Figure 4.1: Real output growth in UK economy (%)



Source: O'Mahony (2002).

Figure 4.1 presents a quite steep decline in output growth during the 1989–91 period, which leads to negative growth figures, followed by a period of increasing output until 1994, with a relatively steady output growth rate until 1999. Overall, the 1989–99 period seems to meet the definition of a business cycle. It is long enough for the purposes of productivity measurement and represents the most recent period.

If volume growth in the comparator sectors is markedly different from that in the rail infrastructure industry, the estimate might be biased. Greater volume growth leads to a higher TFP growth figure owing to the impact of economies of scale. Correcting measured TFP for the proportion owing to volume effects is reasonably straightforward and can be achieved using Equation 2.4 (repeated here for reference).

$$\hat{A} = T\hat{F}P + (1 - 1/\varepsilon_{CQ})\hat{N} \qquad \text{Equation 2.4}$$

Table 4.2 adjusts the sectoral TFP figures to take account of the economies of scale from volume growth. An economies-of-scale elasticity assumption of 0.9 is used for all sectors. This assumption is illustrative, and ideally sector-specific elasticities should be used.

Table 4.2: Adjusting TFP for volume growth (%), 1989–99

	TFP growth	Volume growth	Adjusted TFP growth
Agriculture, forestry and fishing	1.9	0.8	1.8
Mining and oil refining	4.7	2.2	4.4
Electricity, gas and water	3.5	2.3	3.2
Manufacturing	1.6	0.8	1.5
Construction	0.7	0.3	0.7
Transport and communications	3.8	4.8	3.2
Distributive trades	–0.1	1.9	–0.3
Financial and business services	0.4	3.9	0.0
Miscellaneous personal services	0.5	3.4	0.2
Non-market services	2.1	2.4	1.8
Total			
All sectors	**1.1**	**2.0**	**0.9**
Market sectors	**1.0**	**1.9**	**0.8**

Source: O'Mahony (2002).

The figures in this table show that sectoral TFP growth has ranged from –0.3% per annum (for distributive trades), to 4.4% per annum (for mining and oil refining), with the transport and communications sector and electricity, gas and water (where most of the comparator industries to Network Rail can be found) achieving 3.2%.

The transport and communications sector may not necessarily provide an appropriate benchmark for a rail infrastructure company, for two reasons:

- the category is heavily influenced by the communications sector, which can achieve rapid productivity growth from technological change, and has attained a sizeable increase in output in recent years;
- the definition of the transport sector covers mostly activities that relate to the movement of goods and individuals, rather than the provision of infrastructure.

As such, other sectors—electricity, gas and water, manufacturing, construction, and financial and business services—are also used to provide benchmarks. Looking at these sectors and correcting for the effects of scale, the range of possible productivity gains for Network Rail lies between 0% and 3.2%.

However, this benchmark range is based on TFP growth estimates. In order to convert these to RUOE reduction benchmarks, a number of assumptions need to be made—in particular, regarding the rate of capital substitution and future input price growth. The results can be quite sensitive to the assumptions used. Using different assumptions suggests a benchmark range for annual RUOE reductions of 0–4.5%.

5. Summary of the Results

This section examines the top-down evidence and provides some possible interpretation of the results.

5.1 General

Table 5.1 presents a summary of the analysis of RUOE trends for selected industries and companies. RUOE trends have been estimated by calculating the average annual growth rate across the period for which data is available, and adjusted for economies of scale.

Table 5.1: RUOE reductions per annum—summary

	Period	Average RUOE reductions p.a. (%), adjusted for scale
Water industry	1992/93–2001/02	2.5–2.6
Sewerage industry	1992/93–2001/02	0–0.9
Electricity distribution	1990/91–2000/01	3.1–3.8
NGC	1990/91–2001/02	4.6–5.7
NIE	1992/93–1999/2000	3.9
BT, using exchange lines	1995/96–2000/01	3.4
BT, using call minutes	1995/96–2000/01	10.1–10.3
TFP based RUOE implication	1989–99	0–4.5

Source: OXERA analysis.

The historic-cost reductions achieved by other network utility companies (as summarised above) could be used to provide a benchmark range of possible future RUOE reductions for Network Rail. A critical issue is the comparability of these historic performances. Some adjustments have been undertaken to improve comparability, including the following.

- The analysis focuses on privatised (regulated) network industries, since these are regarded as the companies outside the rail industry whose characteristics match most closely those of a privatised rail infrastructure company. In addition, the TFP performance of several other sectors is examined for cross-reference purposes. However, differences between industries remain and the performance in other rail infrastructure companies has not been examined as a further cross-check.

- The focus on privatised (regulated) network industries suggests that the rates of technical progress in each industry should be similar. However, the telecommunications industry, in particular, would be expected to have far higher technical progress than the other utility industries, and thus would be expected to be able to reduce its RUOE more quickly. Thus, BT's performance has been given less weight in the estimation of an overall productivity performance figure. Although the analysis attempted to provide productivity estimates for each industry that are as comparable as possible with each other, it is still possible that differences remain.

- The RUOE reductions have been adjusted for volume growth and the impact of economies of scale. Thus, the adjusted figures provide a benchmark under an assumption of a steady state—ie, it is assumed that future cost drivers, such as volumes, are not expected to show significant growth going forward. However, this adjustment may not be entirely accurate, as the economies of scale estimate is based on other studies not directly associated with the time periods considered.

- In order to take into account the cyclic nature of productivity performance, the TFP comparisons are made over a complete business cycle to avoid misrepresenting the impact of recessionary or growth periods. For the analysis of changes in RUOE in network industries, the effects of privatisation and the regulatory cycle (and the incentives present at the time) have been mitigated by considering, where consistent data is available, the whole time period from privatisation until the present. The relevant regulatory periods are also examined.

- The individual water and sewerage company and electricity distribution company performance results have been averaged across the group of companies in order to mitigate, to some extent, the impact of atypical performance (perhaps due to favourable/unfavourable exogenous factors). In contrast, the NCC, NIE and BT figures are based on the performance of one company. Although provided over a long period, with adjustments to account for extraordinary events where possible, these figures could therefore represent performance not necessarily comparable with the other companies examined;

However, it has not been possible to account in full for other factors that may also affect the applicability of these historic performances, which include the following.

- Different industries may have different proportions of non-controllable costs. Companies with very high proportions of uncontrollable costs will have less potential to reduce their total costs. In this study, it is assumed that the network companies have similar proportions of controllable costs. If using the RUOE reduction range as a benchmark for Network Rail, consideration should be given to its proportion of controllable costs.

- Significant differences in quality enhancements over time may hinder comparisons. For water and sewerage services, some adjustments have been provided by examining base operating costs only. If using the RUOE reduction range as a benchmark for Network Rail, consideration should be given to its future quality-enhancement obligations.

- Historic-cost reductions may need to be adjusted if input price growth is significantly different between industries and over time. Given that the focus of this study is OPEX, the main input factor is labour. It is assumed that there is no significant difference in wage pressure across the utility industries.

- A key driver of cost reductions is the initial efficiency position of a company. No adjustments for this have been made in the figures provided above.

- The focus of the analysis is RUOE reductions and thus input mix and substitution effects will have an impact on the figures. These efficiency measures consider only one input and one output, and do not take into account exogenous factors or the reason for the strength of the cost reductions. The inability of the techniques employed in this analysis to account for multiple cost drivers and their interaction could introduce bias into the estimated productivity performance.

The analysis shows a general fall in RUOE over time for all industries and suggests that, on average and excluding some of the extreme observations, annual RUOE reductions of 2.5–5.5% have been achieved since privatisation. TFP growth estimates provide a range of 0–4.5% per annum.

In addition, the performance over time appears to illustrate that an important factor in producing substantial efficiency improvements is the establishment of strong incentives.

The ranges in Table 5.1 present the RUOE reductions actually achieved by the regulated network companies. Targets set by regulators have tended to be lower than these rates in order to provide the privatised companies with incentives to outperform.[15]

5.2 Upper range of performance

The question of what performance levels have been achieved or the timing of the cost reductions for both the catch-up and the frontier-shift elements is very difficult to answer without resorting to more advanced techniques and making use of more complete datasets. A more ad hoc alternative is to assess the historic productivity performance of a sub-sample of companies in the electricity and water industries. A potential problem with this approach is that focusing on sub-sets of data removes the benefit of the law of large numbers—ie, focusing on short time periods or only one company can result in extreme (high or low) estimates of efficiency improvement due to atypical conditions.

The analysis in this paper has considered:

- the most recent regulatory cycle, due to the relevance of the timeframe (the more recent the period examined, the less likely it is that underlying economic conditions would be radically different);
- the upper-quartile performance over the period (irrespective of whether this was achieved by the efficient or inefficient companies).

It appears that, under relatively higher targets being set by the regulator, higher productivity gains than the identified average for the industries have been achieved. However, perhaps more significantly, the regulatory incentives present in the industry appear to have played a key role in performance improvement. It can be seen from Table 3.3, for example, that the electricity distribution industry achieved savings of around 8.4% per annum for a two-year period, which coincided with the start of the regulatory review period. During this period no rolling incentive mechanism existed and thus the regulatory incentive present was to front-load cost reductions, while the incentive to cut costs in the later years was weakened. It is also apparent that these high cost reductions

[15] Ofwat (2002), 'Setting Water and Sewerage Price Limits for 2005–10: Framework and Approach', October.

were short-lived and the remaining three years of the review period showed average unit cost reductions of only 2.4% per annum, with the result that the average unit cost saving in the industry over the full regulatory cycle was 4.8% per annum.

In the water services, where the most recent full regulatory period spans from 1994/95 to 1999/2000, the upper-quartile performance for that period not adjusting for the increased quality obligations is 3.8% per annum, compared with an average annual performance of the whole industry of 2% (see Table 3.6). The upper-quartile performance when adjustments for quality are made is equal to 5.6%, compared with an industry performance of 3% (see Table 3.7). It appears that the profile of productivity change in the water services in this period (ie, before the rolling OPEX mechanism was introduced) is very similar to that observed in the electricity distribution industry, meaning that the largest productivity gains are achieved early in the period, when incentives are strongest.

The same does not hold for the sewerage services, which examines the same time period as the water services, where productivity improvements appear to reach their peak during the 1996/97–1997/98 period.[16] During the latest full regulatory period, the upper-quartile productivity performance in the provision of sewerage services without adjusting for the increased quality obligations is 1.9%, compared with an industry average of –0.7%. When assessing productivity using base service OPEX, the upper-quartile performance is equal to 5.2%, compared with an industry average of 3.1%.

A similar analysis for the electricity distribution industry, which examines the same time period as the water and sewerage industry, since the regulatory cycles match, reveals that the average annual RUOE reduction of the upper quartile for that period is 6%, compared with an industry average of 4.8% (see Table 3.3).

These results are summarised in Table 5.2.

Table 5.2: Upper-quartile annual average RUOE reductions (%)—summary (1994/95–1999/2000)

Water industry, upper quartile	
without increased quality obligations	5.6
with increased quality obligations	3.8
Sewerage industry, upper quartile	
without increased quality obligations	5.2
with increased quality obligations	1.9
Electricity distribution, upper quartile	6.0

Source: OXERA analysis.

[16] This could be the result of a small dataset examined over a relatively short timeframe, or the fact that only partial productivity measures are considered. Alternatively, it could simply be due to the demands of incorporating the significant quality investment programme into the companies' more day-to-day operations.

These historic-cost reductions achieved by specific sub-sets of the network utility companies (as summarised above) could be used to provide a benchmark range of possible future RUOE reductions for Network Rail, under certain circumstances (and bearing in mind the issues highlighted in section 2 and discussed further in section 5.1). Thus, a number of assumptions are required for these ranges to be relevant, including:

- if Network Rail is assumed to be highly inefficient and thus to have the potential for significant cost reductions. However, for a company deemed to be relatively inefficient, the impact of restructuring costs needs to be considered;
- no atypical performance is evident in these figures—the analysis is based on examining sub-sets of companies within an industry and over shorter time periods than considered in section 5.1. Thus, the benefit of the law of large numbers is lessened. As such, some of the above figures could represent atypical performance perhaps due to favourable/unfavourable exogenous factors (eg, the effects of drought for the water and sewerage industries or severe storms for the electricity industry);
- privatised (regulated) network industries provide comparable trends in performance;
- the industries have similar rates of technical progress;
- the range represents a possible benchmark for a steady state—ie, assuming:
  - zero future volume growth (the figures used in this section are the RUOE reductions adjusted for volume growth and the impact of economies of scale); and
  - no significant future quality enhancements are required;
- strong incentive mechanisms have been put in place by the ORR;
- Network Rail has proportions of non-controllable costs similar to those of the benchmark industries;
- input price growth is not expected to be significantly different for Network Rail in future compared with the historic periods considered or the benchmark industries;
- input mixes and substitution effects are similar across the industries.

The analysis suggests that the upper-quartile performance of privatised network industries is an annual RUOE reduction of 5% or higher, where no significant quality enhancements are required.

5.3 Minimum performance

It is difficult to estimate a possible frontier-shift benchmark for simplistic unit cost comparisons, notably because the frontier company or companies will alter over time, such that the performance of one company cannot directly be used as an indication of the frontier shift. In addition, there are problems relating to the use of sub-samples and partial productivity measures, as well as the other issues noted in section 5.1 and, in particular, 5.2.

The analysis focuses on what other regulated network industries have been asked to achieve, as detailed below.

- For the water and sewerage industry, Ofwat's estimation of the frontier shift for the 2000/01–2004/05 regulatory period was 1.4% per annum. Frontier-shift assumptions for the earlier periods were more modest, with estimates of 1% per annum.

- For BT, during the 1997/98 price-control review, Oftel suggested a frontier-shift estimate of 3% per annum, based on a comparative-efficiency analysis using international comparisons.[17] This figure is significantly higher than that used by Ofwat, mainly because of the higher underlying technological progress observed in the telecommunications industry.

- In the case of NIE, Ofreg put forward a frontier-shift assumption of 1.5%.[18]

- For NGC, the price-control review was based on bottom-up analysis and thus no distinction was made between frontier shift and catch-up in NGC's cost-reduction targets for the current price-control period.

- For the UK electricity distribution industry, Ofgem did not impose a frontier-shift target for the industry for the 1999 distribution price-control review, possibly due to the large cost reductions needed for inefficient companies to catch up to the frontier, and to give increased incentives to the frontier companies to outperform.

From the above, the frontier-shift range requested by regulators in privatised industries lies between 0% and 3%. Excluding the frontier-shift assumption of Oftel (for BT) and Ofgem (for the electricity distribution companies), due to differences in the underlying technological growth and incentive issues respectively, provides an estimate of 1–1.5% per annum.

5.4 Summary

Table 5.3 summarises the ranges developed in sections 5.1 to 5.2.

Table 5.3: RUOE annual average reductions (%)—summary

Frontier shift	Average performance	Upper-quartile performance
1–1.5	2.5–5.5	5–6

Source: OXERA analysis.

[17] Oftel (1996), 'Pricing of Telecommunications Services from 1997: Oftel's Proposals for the Price Control and Fair Trading', June.
[18] The Director General of Electricity Supply for Northern Ireland (2002), 'Transmission and Distribution Price Control Review: Initial Proposals for Northern Ireland Electricity', March.

6. Conclusions

The objectives of this study were to examine:

- the distribution of performance—based on the experience in other industries, how quickly have cost reductions be made?
  - for a company of average efficiency, a reasonable benchmark can be provided by the performance of the entire industry, as this includes the performance of efficient and inefficient companies in the industry;
  - for a company that is deemed to be relatively inefficient, its potential for improvement may be higher than that given by average industry performance;

- a possible longer-term benchmark for general productivity improvements, or frontier shift—in the long run, assuming that Network Rail is reasonably efficient, what additional annual cost reductions could be expected from technological improvements, new management practices, etc, which Network Rail should be able to achieve in addition to the catching up of inefficiencies?

The methodology used in this study was to compare the historic performance of other companies. Such comparisons need to be made on the most like-for-like basis possible. The most direct set of comparators would have been rail network companies in other countries. However, data consistency problems limited the potential comparison with US rail companies. This would have enabled multiple outputs and multiple exogenous factors (and multiple inputs) to have been considered, providing a more accurate assessment of efficiency improvements over time. This would have also enabled catch-up and frontier shift to be estimated separately, including examining the link between relative inefficiency and future productivity improvements—thereby providing direct evidence for the first two objectives noted above.

However, time constraints meant that this approach was not pursued for this stage of the research. Instead, the analysis is largely based on RUOE reduction estimates of companies deemed to be comparable with Network Rail—ie, other privatised network utility companies that operate under some form of economic regulation.

A critical issue is the comparability of these historic performances. Some adjustments have been undertaken to improve comparability, including:

- averaging individual company performance results where available in order to mitigate, to some extent, the impact of atypical performance. The upper-quartile performance figures are more susceptible to this problem than the industry-wide average figures;

- the comparisons are focused on privatised (regulated) network industries, as these are regarded as representing the most comparable industries to Network Rail;

- by focusing on privatised (regulated) network industries, and excluding telecommunications, the rates of technical progress in each industry should be similar;

- the range of improvements represents a possible benchmark for a steady state—ie:

  - no future volume growth is assumed (figures are the RUOE reductions, which have been adjusted for volume growth and the impact of economies of scale);
  - no significant future quality enhancements are required. (Alternative figures are provided where quality enhancements have been significant);

- in order to mitigate the cyclic nature of efficiency performance, the whole time period from privatisation (when consistent data is available) until the present is examined, together with the relevant regulatory periods.

It has not, however, been possible to account in full for other factors that may also affect the applicability of these historic performances, including the following.

- Different industries may have different proportions of non-controllable costs—if using the RUOE reduction range as a benchmark for Network Rail, consideration should be given to its proportion of controllable costs.

- As a benchmark, historic-cost reductions may need to be adjusted if input price growth is significantly different between industries and over time.

- A key driver of cost reductions is the initial efficiency position of a company. Some assessment of this issue is provided by examining upper-quartile performance.

- The focus of the analysis is the use of RUOE reductions and thus input mix and substitution effects. These efficiency measures consider only one input and one output, and do not take into account exogenous factors or the reason for the strength of the cost reductions.

- The strength of the regulatory incentives in place, and the use of ‘carrots’ to provide an incentive to outperform—the historic performance of the utility companies appears to illustrate that a critical issue in producing substantial efficiency improvements is the establishment of strong incentives.

The preliminary results suggest the following.

- On average, annual reductions in RUOE of 2.5–5.5% have been achieved since privatisation, excluding some of the extreme observations. TFP growth estimates provide a range of 0–4.5% per annum. These figures relate to the industries as a whole and therefore represent the performance of efficient and inefficient companies. As such, they reflect average performance.

- Owing to the limitations of the technique used, a robust estimate of the frontier shift could not be calculated. However, based on previous regulatory targets, underlying future productivity improvement appears to be in range of 1–1.5% per annum.

- The analysis suggests that the upper-quartile performance of privatised network industries lies in the range of 5% per annum or higher RUOE reductions, where no significant quality enhancements are required.